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Final Project

Background

Soil naturally erodes over time. Through gravity, rainwater, and wind, levels of soil naturally decrease. However because of human interference, such as construction, urbanization, and inefficient rainwater drainage, erosion may become very detrimental to ecosystems all over the world. Through water erosion, layer upon layer of important topsoil is being stripped away. With each layer that is swept into a nearby body of water go important nutrients, beneficial microbes, and soil particles that are essential to healthy soil, and a healthy ecosystem. Without the organic matter in the soil, the soil loses a considerable amount of nutrients, and causes lack of food for organisms that depend on the organic matter for food. Without sufficient nutrients, plants are not as successful, and herbivores have to live off plants that do not contain a regular amount of nutrients. Simply stated, run-off causes soil to lose it's capability to support healthy plants.

Many important microorganisms that are responsible for a considerable part of a plant's carbon intake are also swept away with the run-off. According to the US Change Research Information Office (GCRIO) (n.d.), when many soil particles are constantly lost to erosion, soil looses its structure, and may even change texture. According to OMAF staff, *et. al*. (2003), with a loss of soil structure and a change of texture, the soil's capability of holding water changes. The soil's inability to hold water causes either severe flooding during storms, or severe drought without storms. A lack of, or abundance of water in the soil not only affects bacteria, but also affects the capability of plants to grow. (Ontario Ministry of Agriculture and Food, 2003)

Whenever the water flow and drainage of an area is changed, it causes a disruption in the entire soil ecosystem. Building and development strips land of its vegetation, and introduces foreign objects into the soil such as concrete, bricks, or metals. According to the USDA Forest Service Southern Region, *et al.* (2001), these foreign objects disrupt the water flow. Without the plants that formally occupied the space, water flows over the area too quickly. The ground can not compensate for the lost plants, and less of the nutrients and minerals are soaked up. The nutrients that are not soaked up go straight into bodies of water, which causes serious problems over time. As more nutrients and minerals leave the soil, the soil becomes less capable of supporting plant and animal life. Also, many of the nutrients that are washed into bodies of water are foreign to the existing ecosystem they have just entered.

Foreign minerals can cause some animal and bacterial life to thrive and others to die, making the ecosystem unbalanced. Man made drainage systems, such as pipes, create an area that receives a greater amount of runoff. According to Christine Rodick (2002), the water was evenly spread out before the man-made drainage system disrupted the path of the run-off, and the ecosystem is damaged by the amount of water moved through these drainage systems. Roadways and parking lots accelerate the movement of run-off, and the oils and other harmful byproducts created by automobiles are swept into both bodies of water and soil (Rodick 2002).

Foreign objects that humans add to the soil such as brick, cement, metal, and “filler” soil, have different textures than native soil. By mixing the textures of these foreign objects with the native soil, we, in turn, permanently change the texture of the soil (USDA Forest Service Southern Region, *et al.*, 2001). Soil texture is the proportion of clay, sand and silt in the soil. There are three common types of soil: clay, sand, and silt. According to Preston Sullivan (2002), clay soils can hold the most water; however, most of the water it holds is not readily available to plants. According to Sullivan (2001), sand cannot hold as much water as clay, but it is easier for plants to soak up the water in sand than the water in clay. Air is also able to flow freely through sand, but nutrients aren't easily stored. In contrast, clay is densely packed together, so it has very small pores. These small pores do not allow easy air flow, but do hold nutrients very well.

A disadvantage to having sandy soil is that water in sandy soil easily evaporates. During long periods of drought or hot weather, water quickly leaves sandy soil, making it difficult for plants and other organisms to survive. As far as size is concerned, silt particles are mid-sized; in-between sand and clay particles. (Sullivan, P. 2001) According to Cheryl Nakamura (2003), it is beneficial to have a mixture of sand, silt, and clay, called loam. By having a mixture of the three soil types, one would have stored water and nutrients, along with air passing through the soil. The Alken Murray Corp (n.d.) says that soil texture can be changed by humus, an organic material on the top of soil that is made by decomposing organic matter Humus creates the ideal soil; it easily holds nutrients and water while still allowing air to flow freely. (Alken Murray Corp. n.d.)

Hypothetically, if a large number of bacteria are absent because of run-off, then the animals that survive by eating the bacteria, or the nutrients that are produced by bacteria, would decrease in number. As a result, other microbes that are immune to pollutants in the run-off would increase. The population density of the pollutants would increase, creating an environment that has a density that is too high for the microbe population to continue successfully living.

Some bacteria are very strong. Actinomycete bacteria can break down cellulose, chitin, and can lower high soil pH. Actinomycetes can also fix nitrogen that can be used by the host plant or nearby plants. According to a website from the University of Minnesota, other bacteria can "exude a sticky substance that helps bind soil particles into small aggregates. So despite their small size, they help improve water infiltration, water-holding capacity, soil stability, and aeration." Soils can create atmosphere carbon dioxide, and fix it when it is damaged. (University of Minnesota, 2003)

The University of Minnesota (2003) has found that bacteria populations are most dense around plant roots because plants provide bacteria with a considerable amount of food. The run-off created by manmade objects kills the plants needed for the bacteria living around them to survive. While David A. Zuberer (n.d.) says that bacteria are "the most numerous microbes in soil," our desire to build and develop land could eventually change this statement. At the present time, it is important that research is done to develop possible ways for humans to expand their infrastructure while still keeping the needs of our "neighbors" in mind.

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Problem:
How does runoff change bacterial density in soil at different distances from the point of origin of runoff?

Hypothesis:
Closer to the runoff location and closer to the soil surface, bacterial density will be lower than the bacterial density of soil samples taken at greater depths and distances from the point of origin of runoff location.

Variables and Controls:

Independent 1- Distance on land from drainpipe on the gymnasium wall
Independent 2- Depth below surface

Dependant- Density of bacteria in soil samples

Baseline Negative Control- The soil sample closest to the drain pipe at the surface
Experimental Negative Control- Soil samples closest to the surface

Control Variable List- plants growing around drain pipe, amount of sunlight received by drain pipe, type of drainpipe, topography of land around drain pipe, sterile water used in serial delusions, use Petri films® to grow bacteria, grow bacteria in a location not in direct sunlight, whether or not drain pipe releases water above or below ground, Petri films® kept at room temperature, wait 48 hours before counting bacteria on Petri films®, dilute soil/water mixture by powers of 10, use a soil core sampler with the dimensions of 2 cm × 15 cm,

Step-By-Step

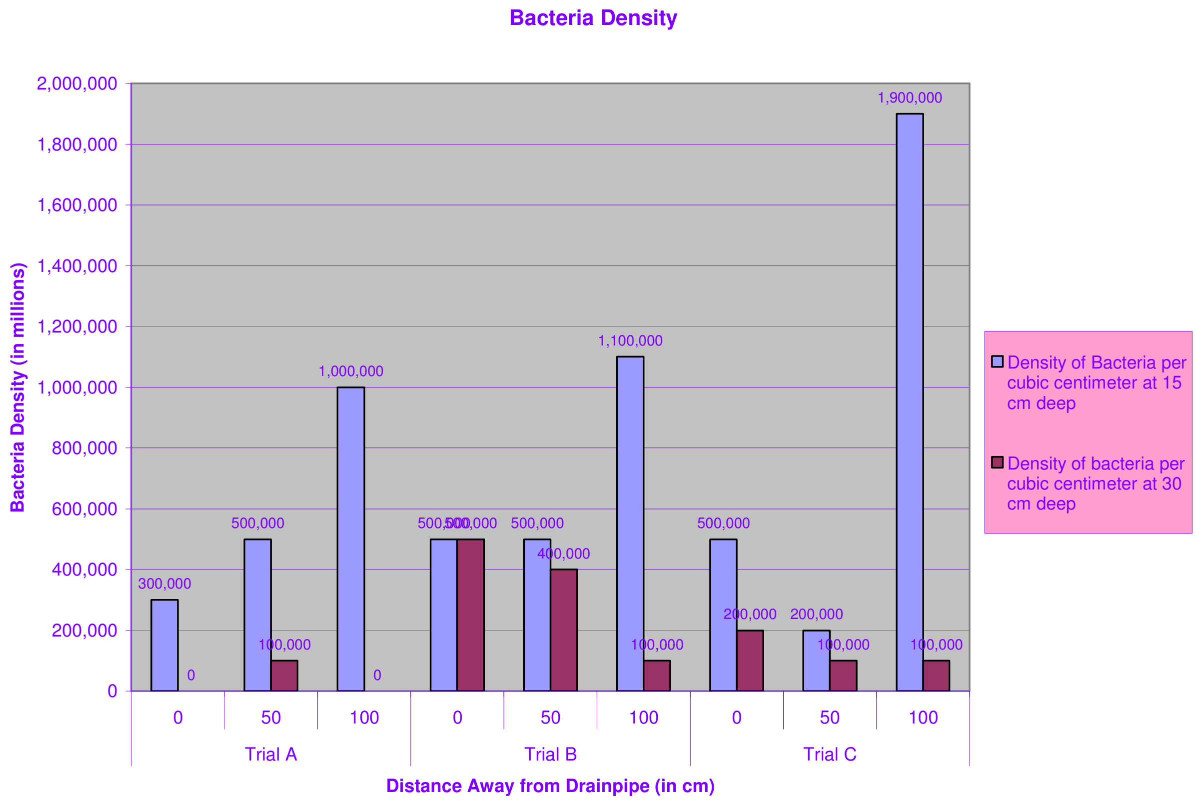
1. Collect soil samples using a soil core sampler (2 cm × 15 cm).
2. All samples from one drainpipe must be collected at the same time.
3. Collect all samples at the bottom of a drainpipe;
   At three measured distances perpendicular to the wall of the building and directly in front of drain pipe:
   a. directly next to drain
   b. half meter (50 cm) away from the first sample
   c. a half meter away from the second one (a total of 100 cm from first sample
   And two measured depths:
   a. 15 cm deep
   b. 30 cm deep
   (Do not take these depth samples in separate locations. Instead, take the 15 cm sample, remove the soil core sampler from the ground, and in the hole just created

by the 15 cm sample, take the 30 cm sample. Each sample should have 15 cm of soil total in the soil core sampler.)

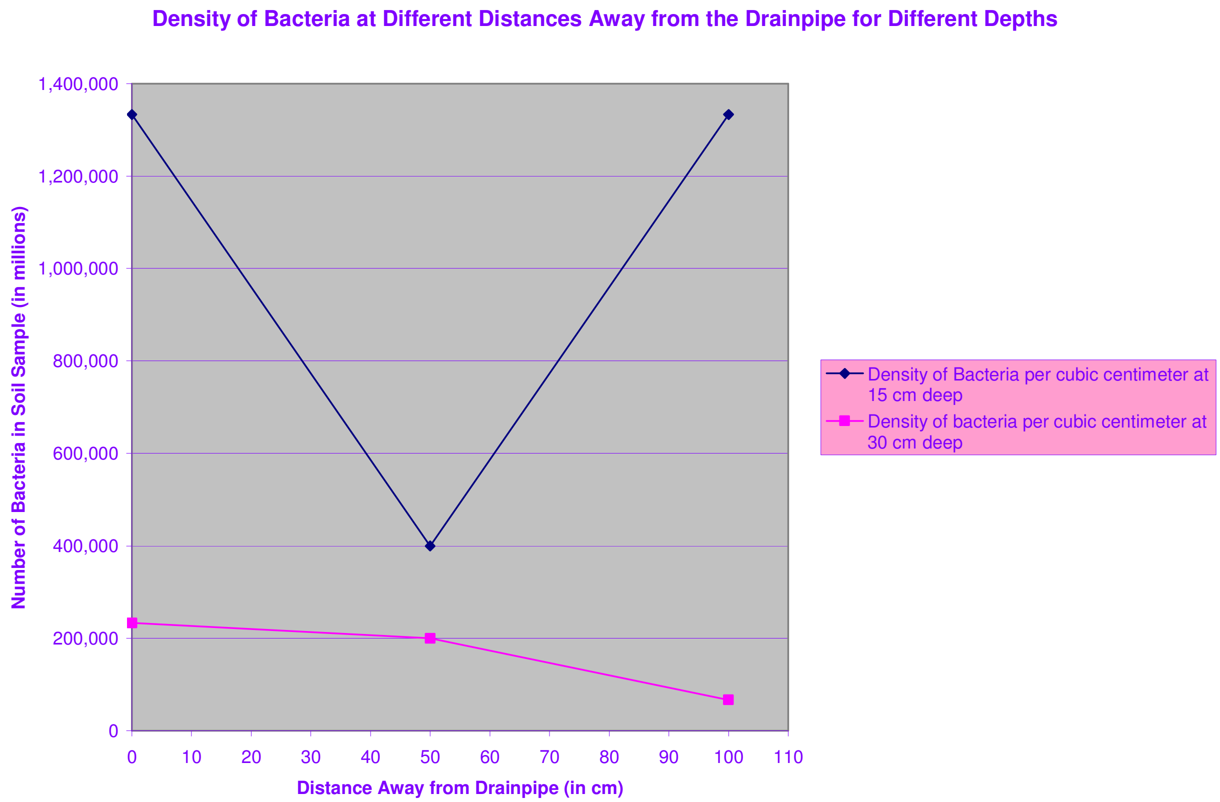
4. Place each soil sample in a separate plastic bag and label all bags with:
    a. the letter of the trial (A, B or C)
    b. the depth of the soil (15 cm or 30 cm)
    c. the number sample it is from drainpipe (1, 2 or 3, with one being sample directly next to pipe)
    d. the date the sample was collected on
5. Repeat the following steps with all of the soil samples from one drainpipe. Conduct all experiments for one specific drain pipe trial on the same day and at the same time.
6. Place 1 cc of the A /#1/15 cm soil sample into a culture tube containing 10 ml of sterile water; cap the tube and shake vigorously
7. Add 9 ml of fresh sterile water to four more tubes
8. Using a serological pipette, remove 1ml of the soil/water mixture from step six and place it into the second fresh culture tube
9. Cap this test tube and shake it a few times to evenly mix all of the soil/water into the sterile water.
10. Repeat step eight using the second diluted tube by removing 1ml of the mixture and placing it into a third culture tube.
11. Continue the procedures described in steps eight and nine until you have diluted the original soil/water mixture a minimum of four times (10^{-4}).You should now have a total of five culture tubes.
12. Plate 100µl samples from the 4^{th} and 5^{th} tubes onto their own separate, individual Petri film® plates with nutrient agar.
13. Allow all Petri film® plates to incubate at room temperature overnight. Do not place the plates in direct sunlight.
14. Examine each of the plates for individual bacteria colonies and choose the plate with the fewest colonies to estimate the number of bacteria the in original 1cc soil sample (# of colonies $\times 10^2 \times 10^{|\text{dilution on selected plate}|}$). Record the data you find after using this formula.
15. Repeat these steps with the soil samples from the rest of the first, and the second and the third drainpipes.

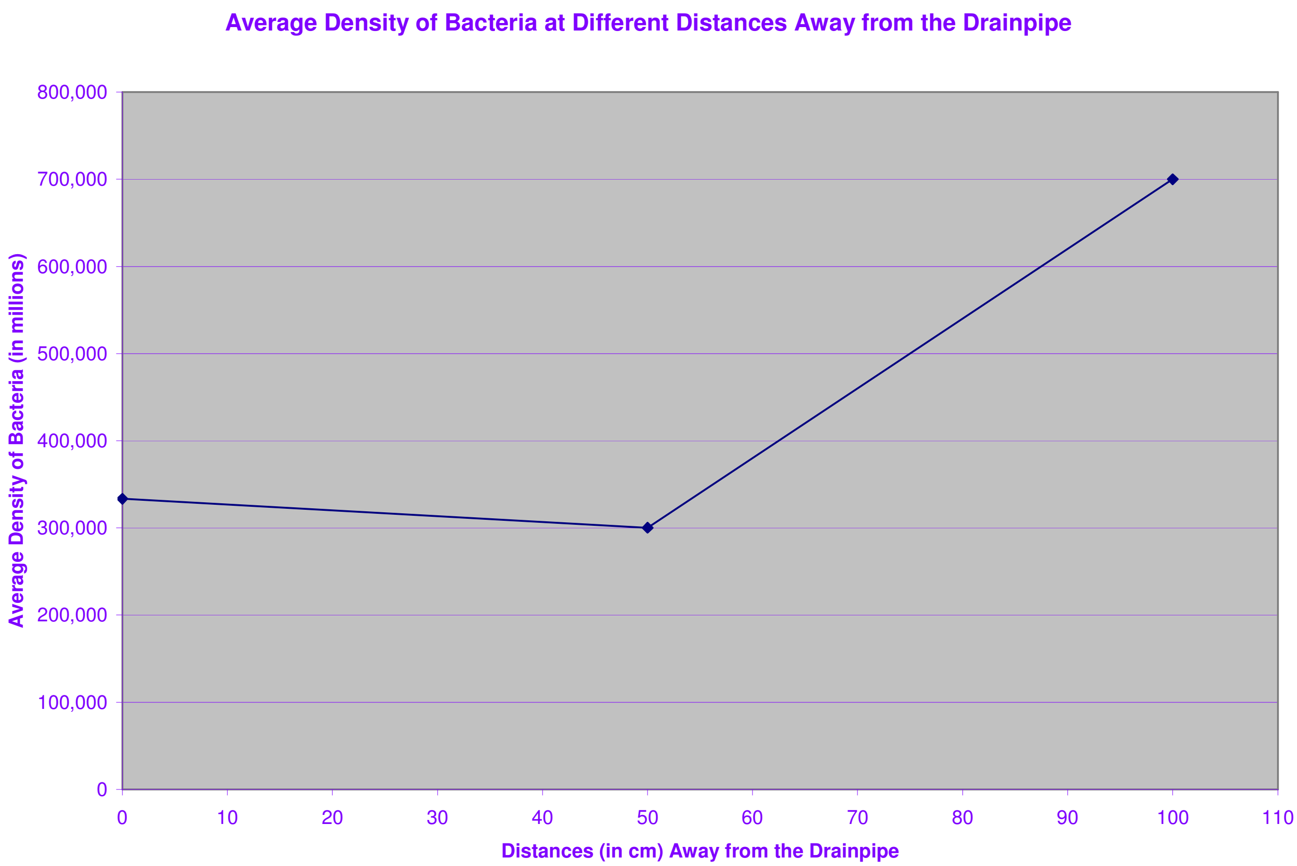
Data and Analysis:

	Distance Away from Drainpipe in cm	Density of Bacteria per cubic centimeter at 15 cm deep	Density of bacteria per cubic centimeter at 30 cm deep
Trial Letter			
Trial A	0	300,000	0
	50	500,000	100,000
	100	1,000,000	0
Trial B	0	500,000	500,000
	50	500,000	400,000
	100	1,100,000	100,000
Trial C	0	500,000	200,000
	50	200,000	100,000
	100	1,900,000	100,000

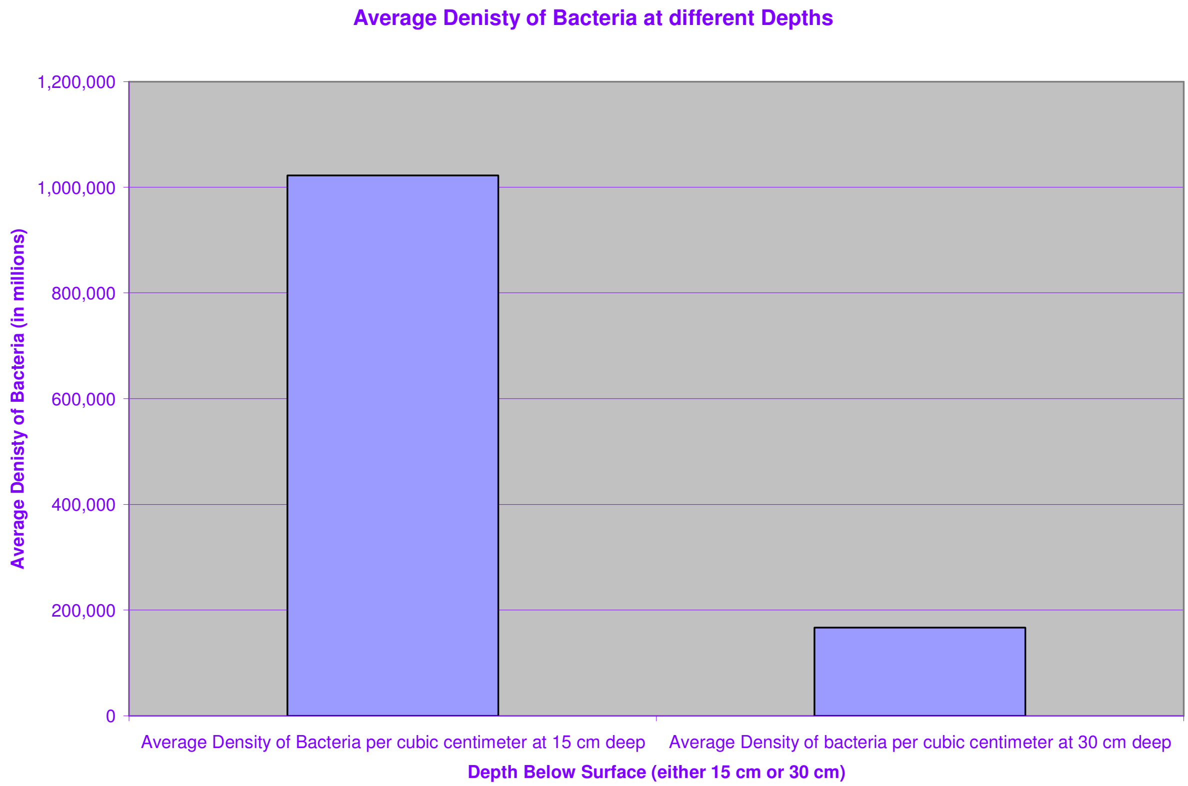


Bacteria Density
Bacteria Density (in millions)
2,000,000
1,800,000
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
300,000
0
500,000
100,000
1,000,000
0
500,000
500,000
500,000
400,000
1,100,000
100,000
500,000
200,000
200,000
100,000
1,900,000
100,000
0
50
100
0
50
100
0
50
100
Trial A
Trial B
Trial C
Distance Away from Drainpipe (in cm)
Density of Bacteria per cubic centimeter at 15 cm deep
Density of bacteria per cubic centimeter at 30 cm deep


Density of Bacteria at Different Distances Away from the Drainpipe for Different Depths
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
Number of Bacteria in Soil Sample (in millions)
0
10
20
30
40
50
60
70
80
90
100
110
Distance Away from Drainpipe (in cm)
Density of Bacteria per cubic centimeter at 15 cm deep
Density of bacteria per cubic centimeter at 30 cm deep



Average Density of Bacteria at Different Distances Away from the Drainpipe
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Average Density of Bacteria (in millions)
0
10
20
30
40
50
60
70
80
90
100
110
Distances (in cm) Away from the Drainpipe



Conclusion:

This experiment was based on the idea that runoff from drainpipes affects bacteria population density negatively. The hypothesis for this lab was that the closer to a runoff location, and the closer to the soil surface at that location, bacterial density will become lower than the bacterial density of soil samples taken at greater depths and distances from the point of origin of runoff location. According to this hypothesis, the greatest bacterial density should have been at 100 cm away from the drain pipe (along the ground), and at 15 cm down. However, our hypothesis was incorrect. According to trends in the data collected in trials A, B, and C, bacterial density at 15 cm down was almost always greater than the bacterial density at 30 cm down. Only once in all three trials was the bacterial density at 15 cm down not greater than the bacterial density at 30 cm down. This instance was in trial B, where, at 0 cm away from the drainpipe along the topsoil, both readings for 15 cm and 30 cm down were the same (~500,000 bacteria per cubic cm).

Another interesting observation that can be made from trials A, B, and C, is that all three trials show that the bacterial density at 30 cm down, and measured going away from the drainpipe, the bacterial density decreases. This is logical, because the site chosen for this lab was on a hill, so it is possible that all of the drain water went out and down, rather than going back to the surface on the way down the hill, causing the bacteria to disappear below ground. This also supports that on average, bacterial density increased in 15 cm down samples of soil, as the samples were taken going away from the drainpipe. This shows a possible error in the lab. This error is that because the site chosen to take samples was on a down-slope. In order for the data to fit the hypothesis, a flat surface would have been required. Otherwise, there is no way to control the way the water flows away from the drain pipe. Something that would have been helpful to know would be the depth at which the drain pipe released the runoff, however this information was unavailable to our group. This would have aided while determining at what depth to collect soil samples.

From our data we can conclude that runoff negatively affects the bacteria population. Even by looking at the drainpipes, we could see that there was little grass or other plant life directly next to the pip bottom. Because the heavy amount of water kills the plants, bacteria are not able to survive. Not only is all of their food killed, but there are also foreign organisms in the runoff that can be harmful to the bacteria. For future research on runoff, we would test for fungi because fungi can live in harsher environments than bacteria can. Also, we would test for the specific chemicals and pollutants that are in runoff. Experimenting with the different methods of runoff control would also lead to new data, and possibly new techniques that would better help our environment.